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Research, Technology Transfer, and Education Needs Assessment for Non-Residential Wood Structures in California

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Abstract

Market share growth for wood products in the area of non-residential construction will require research, technology transfer, and education for architects, engineers, general contractors, and others involved in the decision-making process. To accomplish this in the most efficient and cost-effective manner, an assessment of user-based needs is desirable. This paper summarizes the results of three half-day needs assessment workshops with design professionals and wood product suppliers from southern California. From these workshops, an overall assessment of wood as a building material was formulated and recommendations were made for new products and systems, research activities, and education and technology transfer. This assessment will serve as the basis for development and implementation of a national research program for wood-frame non-residential buildings through the U.S. Forest Service, Forest Products Laboratory, FPInnovations, and the Coalition for Advanced Wood Structures.

Keywords: Wood, non-residential, research, technology transfer, needs assessment, priorities, design, construction

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Research, Technology Transfer, and Education Needs Assessment for Non-Residential Wood Structures in California

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Introduction

Wood has been used as a structural material in North America for hundreds of years. Historically, the primary markets for structural wood applications have been single- and multiple-family housing and transportation structures such as bridges. Although wood has been used with a good performance record in non-residential building applications such as schools, hotels, strip malls, and offices, the relative market share for wood has been small compared with that of other construction materials.

In recent years, the combination of strong, rising domestic wood production capacity, weak demand for structural wood products, and increasing competition worldwide has driven the wood products industry to pursue enhanced access to markets that could consume additional wood products. In relation to other opportunities, the non-residential building market compares favorably because it is large, the opportunity to gain share is high, the challenges are not overwhelming, and positive results can be achieved in a reasonable time period. In response to this opportunity, the North American wood products industry formed the Wood Products Council (WPC) and initiated action on a multi-year, multi-million dollar marketing, technical, and technology transfer program to increase the non-residential market for wood.

Previous investigation has identified that the hurdles to be overcome are a lack of knowledge and education in wood design and a lack of simple solutions to common problems associated with durability, maintenance, codes, design, and connections. Research applicable specifically to markets targeted by the WPC is required to ensure that the obstacles and their solutions are well understood.

The U.S. Forest Service's interest is to develop a national priority-based assessment of relevant research areas and topics related to wood-frame non-residential construction. These findings will provide guidance in research program development and implementation. The WPC's interest is to understand the challenges that must be addressed to remove the barriers to wood use in the non-residential market. Additionally important is how research, technology transfer, and education results can be integrated into a marketing effort required to achieve market growth.

The first geographic focus of this effort was in California because wood is generally accepted and the local design community has a degree of familiarity with and expertise in wood use. Our assessment also determined that California had the highest market-share growth potential of any geographic area in the United States. This assessment will serve as the basis for development and implementation of a national research program for wood-frame non-residential buildings through the Forest Products Laboratory (FPL), its Canadian counterpart, FPInnovations, and the Coalition for Advanced Wood Structures (CAWS).

Objective and Scope

The objective of this study was to compile a summary of user-identified research, technology transfer, and educational needs for wood-frame non-residential buildings in California. The scope was primarily focused on material selection, design, and construction, but other topics such as maintenance, rehabilitation, and replacement were also considered.

Methodology

To accomplish the objectives of this study, two half-day focus group workshops were held with structural engineers and architects in Irvine, California, on June 5 and 6, 2007. Eighteen design professionals representing some of the top wood-design consulting engineering firms from southern California, senior researchers from FPL and FPInnovations, and representatives of the wood products industry participated. Additionally, one half-day focus group workshop was held on June 5 with representatives from four major

companies that supply wood products to the southern California non-residential building market. The observations and recommendations from each of the focus group workshops were recorded and consolidated under similar headings in this paper.

Results

The summarized results of the focus group workshops were categorized into an overall assessment, plus recommendations for new products or systems, research activities, technology transfer, and education. A combined overall summary of these areas for all workshops follows. Detailed recommendations from individual focus groups are in the Appendix.

Focus Group Overall Assessment

When wood is used in non-residential construction, it is often because wood is the low-cost option, and this is important to owners and contractors. If wood can meet the design and performance requirements for a particular project and the designer is familiar with using wood, wood will usually be considered. Contractors are a key part of this decision-making process, and they must be comfortable using wood.

Unfortunately, in recent years wood has been losing its share in some applications, such as commercial roofs. In addition, the trend toward bigger store-front openings requires some type of moment frame that cannot be easily achieved with wood construction. A moment frame is a box-shaped frame with special moment connections or joints that help in resisting wind and earthquake damage. The frame helps a building to flex as necessary to retain the building's structural integrity. Seismic requirements in recent code changes are becoming increasingly problematic for wood. Also, the tendency of eastern designers affiliated with large developers to consider only steel is moving into the California market. Therefore, there is a risk of substitution in other key segments where wood-frame construction has traditionally dominated, such as multi-family construction.

Image Problems for Wood

Several of the participating engineers noted that wood is generally not considered to be a modern construction material and is often perceived as a "second cousin" to steel and concrete. Some designers view wood mostly as a residential construction material and not an engineered material for non-residential uses. One example cited was that it is difficult for wood buildings to get a leased office space "A" rating because this rating is typically restricted to Type I and Type II non-combustible construction.

Design professionals generally do not consider wood to be a "green" building material. The U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) program, the dominant green building rating system in California, appears to favor steel and be biased against wood. Therefore, if a green rating is required, designers typically turn to steel.

The design community appears to be confused about the benefits of renewable (wood) compared with recyclable (steel) materials, and the sustainability aspect of wood needs to be better promoted to groups such as the USGBC. In addition, greater emphasis needs to be placed on life cycle assessment when comparing building materials to determine their true environmental impact and thus improve the image of wood as "green."

The industry needs to address confusion about various forest certification programs such as the Forest Stewardship Council, Sustainable Forestry Initiative, and the Canadian Standards Association and LEED, which only recognizes Forest Stewardship Council-certified wood products.

Design Methodology

Concrete is designed using only load and resistance factor design (LRFD), and steel is moving in that direction. Although an LRFD standard exists for wood, it is lagging behind the other materials in its implementation. This adds to the perception of wood being considered "old-fashioned," although the current National Design Specification for Wood Construction includes an LRFD design methodology in parallel with allowable stress design (ASD) methodology. While most of the current generation of wood-design engineers prefers ASD, this creates a problem for hybrid or mixed construction because of the difficulty of tracking loads under mixed ASD and LRFD methodologies. The wood industry needs to move forward with implementing LRFD design in California, as many structures are hybrid and combine wood with steel or concrete or both.

University Education

The universities in California are generally not teaching wood design in civil engineering departments. If wood design is taught, it is usually an elective and space is limited. Thus, when firms hire recent graduates as junior engineers, graduates have a basic understanding of steel and concrete design but not wood. Firms that do wood design often teach it to the junior engineers, but this is not an option for those firms who do not routinely design with wood. And the experienced wood-design firms are finding it more difficult to find time to train their junior designers in the art of wood design. Further, LRFD or limit state design is being taught in the concrete- and steel-design courses, whereas ASD is typically taught in the wood-design courses; this is a further deterrent to using wood.

Lack of Ease of Use

In general, steel and other materials are easy to design with and wood is perceived to be more difficult. This is due primarily to the complexity of the connections associated with wood design and the myriad of commodity and proprietary wood products from which to select.

- If additional capacity is needed for load transfer at a steel connection, additional welding will usually solve the problem. This is not true for wood, which may require a

complete re-engineering of a connection. In other words, what might work for a relatively light load may need a totally different type of connection for higher loads.

- Designers have excellent steel and concrete design software, but no comparable software exists for wood design. The American Institute of Steel Construction (AISC) offers design consultation services on their website, and the masonry industry also provides design assistance.
- Most non-residential buildings with three stories or less are steel, and concrete is often used for four-story buildings and higher. This makes steel the primary competitive product to wood. A steel-frame structure is easy to design with high-end software and welded connections. Because engineers have a fixed-fee structure, using steel can mean higher profits because it takes far less time to design a steel structure compared with wood.
- A typical steel building may have 4 to 6 pages of detail drawings, whereas a comparative wood building may require 30 to 40 pages of drawings. Developing these details is costly and detracts from the consultant's fees. For experienced wood designers, this is not a major deterrent because they have developed many details in advance. However, firms that do not design with wood are less likely to take the time to develop these details and will stay with what they know (which is steel).
- Selecting the design properties of a steel product is simple, with limited choices for both the main carrying members and the secondary members. The steel stud industry has standardized its product line so that companies all make similar products. Wood offers dozens of options for generic products such as lumber and glulam and even more choices for proprietary products such as I-joists and structural composite lumber. The wood industry needs to standardize these products through some type of stress-class or rating system. Engineers are reluctant to specify a proprietary product because the contractor may make a product substitution based on local product availability or cost, which can require re-engineering.
- Designers prefer steel for floor spans over 30 feet because they think that wood is difficult to use when a high-diaphragm shear capacity is needed in large buildings and more vibration issues are associated with lightweight wood floors. They also don't like to use wood when a precise straight wall is required, which is more easily achieved with steel studs.
- Designers have concerns about the skill of general contractors and subcontractors who work on wood projects, mostly because many workers cross over from the low-skill residential labor pool. This potentially requires the engineer to do more on-site quality control, as contractors generally don't understand seismic issues well enough to recognize the complex engineering details associated with wood design.

Focus Group Recommendations for New Products or Systems

The design professional focus group results identified several ideas for new products or systems that could increase the use of wood in non-residential buildings. For newly developed products to be easily adopted, they need to be cost competitive, have all necessary code approvals, be readily available, have good performance values, and be standardized. Following are recommendations in this context:

1. Not much has been done to improve wood-diaphragm and shear-wall design for many decades. New concepts are needed, such as the pre-engineered drop-in shear panels now available from several manufacturers.
2. Many projects require large wall openings that can be easily accommodated by steel moment frames. The wood industry needs to develop comparable wood moment frames. One approach may be the post-tensioned heavy timber frames currently being researched in New Zealand.
3. Better connections are needed for wood systems to resist high lateral loads imposed by seismic events. Lateral ties of wood roofs to concrete walls are particularly important. For example, self-tapping screws should be implemented in North American wood-design codes.
4. The wood industry should continue to refine fiber-reinforced polymer (FRP) wood reinforcement products and introduce them into the marketplace through code acceptance reports.
5. The Tilt-up Concrete Association, representing the tilt-up concrete wall industry, routinely conducts research on combining metal roofs with tilt-up concrete walls. A similar effort for combining wood roofs with concrete walls should be initiated. Cross-laminated timber (CLT), a product that is gaining popularity in Europe, can be a good wood-based candidate to compete against tilt-up concrete in non-residential construction.
6. More research is needed on the performance of perforated shear walls under seismic loading.
7. A mechanics-based approach or finite-element analysis is needed for the design of shear walls with openings.
8. The interaction of acoustics, fire, and structural needs in wood-frame buildings must be addressed through research.
9. The wood industry needs to investigate whether the property insurance industry is creating incentives to use non-combustible materials.

Focus Group Recommendations for Research Activities

Recommended activities aimed at simplifying the use of wood for engineers (both in terms of the regulatory

environment and in terms of their workload as designers) include the following:

1. Increased use of wood systems and products in combination with other materials is a crucial opportunity. An important means to achieve this is through simplicity and consistency in design philosophy (such as moving toward the use of an LRFD methodology).
   - Technology transfer activities related to LRFD use for hybrid buildings, including information on related issues such as fire, acoustics, seismic, and energy, and pre-engineered "cookbook" examples should be offered for typical wood structures.
2. Standard designs and connections are important to simplify the design and use of wood products. Recommendations in this context include—
   - Developing more hybrid and non-hybrid systems
   - Simplifying proprietary engineering for proprietary wood products
   - Offering packaged technology transfer activities and teaching current options and opportunities
3. Standard products are important to simplify the selection of wood products. The wood products industry needs to develop standard stress-class systems for lumber and glulam and a comparable system to identify proprietary products, such as I-joists and structural composite lumber. To achieve this objective for each product category, the design classes would have to be defined, manufacturers convinced to participate (some testing of proprietary products may be necessary), and follow-up efforts undertaken to ensure that the results are recognized in building codes.
4. Improved or new design software is an important means to achieve some of the required simplification. Current software packages, including the Canadian Wood Council (CWC) Wood WORKS! and manufacturers' proprietary software, are not sufficient for the needs of engineers. Some of the more experienced wood-design firms have developed Excel spreadsheets to solve lateral designs for both rigid and flexible diaphragms as a possible option. These custom-designed spreadsheets need to be eventually packaged with a "whole building" design system.
   - Software solutions should be sought by either improving on the CWC's existing Wood WORKS! software, or partnering with proprietary companies such as The RAM Structural System (Exton, Pennsylvania) or RISA structural analysis and design software (RISA Technologies, Foothill Ranch, California), which already dominate the non-residential market for steel and concrete design.

Activities Aimed at Filling in the Wood Information Gaps

Research is needed to better define the performance characteristics for wood diaphragms (both flexible and rigid), shear walls, connections for lateral design, and floor performance. This research must lead to simplified design procedures for these components of a building system. Recommendations in this context include assessment and development of innovative opportunities related to the following:

- Braced frames
- Moment-resisting frames
- Mixed material systems combining wood with steel or concrete
- Material hybrids combining non-wood reinforcement with wood
- High-load diaphragms for combination with tilt-up concrete and other wall systems

Activities Aimed at Developing New Research Products that Better Meet the Needs of Engineers

Innovative solutions, such as putting steel ends on wood members so they can be welded, should be considered along with the FRP and CLT technologies for enhancing the performance characteristics of wood to change its image of being a second-class product.

- Given this context, we recommend research and technology transfer related to commercializing innovative products.

Focus Group Recommendations for Education and Technology Transfer

Focus groups identified several needs in the areas of education and technology transfer to increase use of wood in non-residential buildings. Although research and new product solutions are important to increase wood use in the non-residential market, increased education and technology transfer—as they relate to current research and knowledge—could provide considerable payback in the short term. Representatives of the steel industry call on engineers frequently with good design information. Examples of booklets from the masonry institute and "steel tips" from the American Institute of Steel Construction (AISC) are good models. Conversely, calls by representatives of the wood industry are very infrequent and are usually made to promote proprietary wood systems. Therefore, wood industry representatives need to call on engineers with creditable design information. Following are more examples of how the wood products industry can be proactive:

1. Whereas research data are available within the wood products industry, we do not often communicate these data to the design community. We need to bridge the gap

between research and designers through better technology transfer of this information.

2. Develop standardized connection details for commercial building designs, particularly for lateral loads
3. Create a set of design aids (handbook) that will simplify the design of a wood-frame structure
4. Develop one or more pre-engineered designs of simple wood-frame buildings that could be peer-reviewed and shared with designers not familiar with wood design. This would walk them through a typical wood-design process.
5. Simplify the process for wood designs to make it easier for a number of users, including designers, plan checkers, inspectors, and contractors.
6. Develop sophisticated computer software that will analyze all loads imposed on the structure, track the load paths, size the members, and design the connections between members. Having only member-design software is not adequate.
7. Material suppliers will often provide basic design solutions and software for their proprietary products, but they are typically only component-based solutions and not entire building design solutions as available to designers through other software.
8. Conduct research on fire-rated assemblies to develop more cost-competitive systems, especially for light-frame wood construction.
9. Communicate more effectively to avoid reinforcing the image of wood as a “non-modern” product.

In addition to the specific recommendations noted above, the wood products industry needs a strong generic sales kit and a better system for communicating and influencing engineers. The focus groups identified several education and technology transfer activity recommendations in this context:

1. Reviewing existing academic and practical technical information to identify new communication opportunities.
2. Assessing existing education and technology transfer materials for knowledge gaps; for instance, good material on price comparisons.
3. Supporting a strong information management and dissemination system, including—
   - A one-stop shop to simplify the transfer of information
   - A search-enabled library of existing technical information
   - Online continuing education opportunities
4. Facilitating best practices and other synergy opportunities.
   - Holding annual gatherings of the marketing, research, and academic communities working to expand wood use, including offshore participation.
   - Seeking means to increase the number of education hours in key universities.

Concluding Remarks

Although wood has dominated the market as a structural material for housing, numerous obstacles must be overcome for wood to fully capitalize on opportunities in the non-residential building markets. The results from the workshops held in California indicate that these obstacles range from basic image to a lack of wood-related university courses and insufficient design aids. In addition, designers lack confidence in using wood in engineered buildings. It is vital that code acceptance and design tools are provided for wood-based systems so that they can be used alone or in combination with systems made with other materials. It is also imperative that design values for wood-based materials are simplified under strength classes. The information compiled from these workshops will be used by FPL, FPInnovations, and CAWS as a basis for developing future research and technology transfer programs. In so doing, we recognize that additional high-priority projects may surface as research is completed and the use of wood in non-residential structures develops further. The process of project identification and prioritization is considered to be a dynamic one, and additional input related to research needs will be solicited from interested parties in the future. By allowing for a free exchange of information and ideas, both the effectiveness and efficiency of completed research will be maximized to provide the greatest national benefit.

Appendix—Detailed Focus Group Notes

Workshop No. 1—Engineers—June 5, 2007

General Observations Regarding Wood as a Non-Residential Building Material

1. Wood design is not taught in civil engineering courses in universities.
2. Many designers consider wood to be suitable only for residential construction.
3. Wood is not seen as a "modern" material.
4. Wood lost the panelized roof market to steel in the early 1990s, and the wood industry has had no success in regaining this market.
5. Hybrid designs using steel girder trusses, steel bar joists, and wood structural panels are the norm, representing millions of square feet of roof area in California each year.
6. The hybrid system is more cost effective, but because of a lack of diaphragm capacity in wood systems, the wood industry is at risk of losing the decking market to steel.
7. Expansion of steel is a problem for large roofs because it leads to leaking. Because wood is more stable than steel, the wood industry should capitalize on this.
8. Because of the requirement for early fire suppression and fast response sprinkler systems in larger roofs, use of trusses for secondary members is imperative.
9. Commercial buildings are engineered, and to compete with steel and concrete, wood needs to have a ductile design based on load and resistance factor design (LRFD). A common perception among owners, architects and engineers is that wood is not an engineered product.
10. Because of load path issues, LRFD for wood is needed for hybrid structures.
11. Designers are reluctant to move from familiar allowed stress design (ASD) to LRFD for wood.
12. The lack of education in wood design at the university level is a deterrent to the use of wood.
13. Current designers have to teach wood design to junior engineers.
14. Contractors and developers are getting more involved in the decision-making process, but they often understand steel and not wood framing.
15. Some contractors drive projects to wood use because of cost and availability.
16. Public perception is that wood is the least expensive building material in southern California.
17. Staff architects from the east are developing corporate prototype steel roofs. The influence of this eastern construction method is moving into California and working against wood.
18. Designers can make more money designing with steel because less detailing is involved and they can optimize their design time.
19. When floor spans exceed 30 to 40 feet, steel becomes the preferred choice because of depth limitations and potential vibration considerations.
20. Wood framing problems include moisture intrusion and durability.
21. Tenant occupancy can cause moisture problems in a wood structure.
22. One advantage of wood is the labor pool available to work on wood construction jobs.
23. Composite wood products and systems, not sawn lumber, are the future.
24. Shifts in material uses come in response to cost changes.
25. The code needs high-load diaphragm tables.
26. Standardization of the vertical-load carrying system will help promote the use of wood; a standardized lateral-load carrying system will come later.
27. Focus should be on the inherent capabilities of wood and not on the steel and concrete competition. Certain types of buildings just favor certain materials.
28. One big concern that the wood products industry should have is losing wood multi-family residential opportunities to metal studs, sheet metal shear walls, stucco exterior, and drywall interior.

Obstacles Facing the Wood Products Industry's Ability to Expand the Use of Wood in Non-Residential Construction

1. The interaction of acoustics, fire, and structural needs must be addressed.
2. Retail shopping centers are requiring more openings where it is difficult to develop wood-framed shear walls. This is driving designers to select steel moment frames over wood moment frames.
3. The design of the lateral design system needs to be simplified.
4. Seismic ties for wood-frame roofs are expensive. Also, the multiplicity of connectors available that make design confusing is a deterrent.
5. Seismic connection designs are becoming more difficult for wood as higher seismic loads are imposed on a structure.

6. There is nothing new in wood shear walls. Higher capacities and higher shear wall and diaphragm test results in the codes are needed.
7. Because load transfers are not intuitive, stacking wood shear walls is a problem.
8. The ability to weld steel connections is a huge advantage for steel; therefore, the wood industry needs to develop wood connections that are simple and intuitive for designers.
9. The level of detailing is more complex for wood; an example is the edge nailing of diaphragms, which is critical for performance.
10. Designers who are not familiar with wood design face a huge challenge in developing details.
11. Multiplicity and availability of lumber products is a problem. To ensure availability for each geographic area and to avoid a redesign, designers often specify the low end of the lumber spectrum.
12. The need exists for simplified design choices for wood.
13. A stress-class system similar to Europe's would provide advantages for the lumber industry.
14. Proprietary products have similar problems; therefore, the industry needs standardization for structural composite lumber and I-joists.
15. The proliferation of glulam combinations is confusing.
16. Proprietary product substitution is a problem, and the evaluation is often done at the shop drawing level, which may require redesign.

Introduction of New Technologies

1. Fiber-reinforced polymer (FRP) products need more than one supplier and must have code acceptance.
2. Fiber-reinforced polymer glulam seems to offer a solution for longer spans, which will allow depths to be minimized.
3. Group members expressed interest in FRP panels for high-load diaphragms and shear walls.
4. The panel questioned whether wood could be reinforced with other materials, such as steel fibers.
5. Research in New Zealand on wood moment frames may have potential for addressing seismic concerns.

Research Needs

1. Connection of wood roofs to concrete tilt-up walls is a concern, so research on connection details is needed.
2. Wood framing is incompatible with concrete; for instance, does the flexible diaphragm actually redistribute the loads?
3. The design of flexible versus rigid diaphragms is confusing in the codes. Can research be conducted to support the use of flexible diaphragms?
4. Research is needed on 2- and 4-hour fire-rated walls; for instance, can the plywood diaphragm penetrate through the wall, which is important from a seismic performance standpoint?
5. Rigid walls and flexible diaphragms need to be reanalyzed to determine how loads are transferred. Research is being conducted by the metal deck industry that could be detrimental to wood.
6. In two-story construction, what should the second floor be? A steel and concrete composite floor has a solid feel compared with wood, and heavy concentrated load distribution is better with a steel and concrete composite floor. Therefore, there is a need for an alternative wood floor system, perhaps a wood and concrete composite.
7. Wood is fine for one-story schools, but steel is preferred for two-story construction because of the perceived floor performance. In addition, durability is more of an issue with wood and a 30-foot classroom module is more of a design challenge for wood.
8. A perception exists that a wood floor is not as good as a steel–concrete floor, so a technology transfer solution would be useful.
9. Designers and contractors are using steel studs to obtain straight walls. Structural composite lumber studs could be a solution for wood.
10. Consider partnering with the drywall and stucco industries to develop better composite wood wall systems.
11. Consider using an adhesive to stiffen joints.

Education/Technology Transfer

1. Develop a handbook that simplifies the wood-design process.
2. Bridge the gap between research and designers through better technology transfer.
3. Complicated designs tend to go to steel because connections are easy to design and software is available. New software addressing connection design could possibly solve some of the complex design issues for wood.
4. Wood has the least available software packages, and the Canadian Wood Council's Wood WORKS! is not sophisticated enough for California designers.
5. Design aids and software need to address the design of "bread and butter" structures and not necessarily the "unusual" one-of-a-kind project.
6. The wood industry needs to get better information to the designers, such as "steel tips" from the American

Institute of Steel Construction and the design aids from the masonry industry. Both are very beneficial to designers.

7. A step-by-step design process could help new designers. This would probably work best for components and should not become too prescriptive.
8. A standard set of details for wood design frame systems is needed.

Workshop No. 2—Vendors/Suppliers—June 5, 2007

General Observations Regarding Wood as a Non-Residential Building Material

1. Schools and retail stores are good opportunities for expanding wood as a building material.
2. The market is good, but builders hesitate to move forward because of economic constraints.
3. Although bidding activity is high, conversion is low. Therefore, contractors are sitting on projects.
4. Codes and local jurisdictions need to be positively influenced about using wood in non-residential construction.
5. Wood continues to lose to steel in industrial markets.
6. The wood industry needs to work with engineers to not over-design structures.
7. "Green" should benefit wood, but LEED does not favor wood. LEED promotes recyclability and not renewability.
8. That LEED only permits the use of wood certified by the Forest Stewardship Council hurts wood and drives the cost up.
9. Although the wood industry is designing to a stiffer criteria and floor spans do not seem to be a major concern, a perception exists that steel is better.
10. The question is who makes the product decision that depends on the end use? This is different whether the end use is industrial, office buildings, or strip malls.
11. Designers are requesting standardized products, standard connections, and standard assemblies.
12. Engineered wood products are driven by innovation, and this might not continue if products are standardized.
13. The availability of multiple wood products leads to cost-efficiency.

Obstacles that Face the Wood Products Industry for Expanding the Use of Wood in Non-Residential Construction

1. Wood education is not being taught at the university level; therefore, junior engineers must learn wood design on the job.
2. Seismic requirements after the January 17, 1994, Northridge earthquake in the San Fernando Valley region put a huge strain on traditional wood connections, whereas steel connections can use additional welding to resist increased forces.
3. Wood construction tolerances can lead to misapplication of wall straps to purlins using proprietary straps. This has disappeared as an option and has been replaced by very expensive hold-downs and other anchorage systems.
4. Engineers are used to designing with steel and can easily add a few extra inches of weld; this is not easy to achieve with wood.

Research Needs

The wood industry needs to study—

1. The corrosion of connectors with new preservative treatments, which is becoming a problem in commercial construction in California.
2. Whether property insurance rates are fair and equitable for both wood and steel framed buildings when comparing the cost of insuring buildings.
3. A more cost-competitive single layer gypsum 1-hour fire-rated system for light wood-framed construction.
4. Engineered wood product studs, which could be an opportunity for some unusual applications, such as long lengths.

Education/Technology Transfer

1. Software is needed that is competitive with that provided by the steel industry.
2. Contractor education to minimize misapplications and callbacks would be beneficial.
3. There is a need for a stronger role in "green building" activities.
4. Lunchtime meetings are a tool used by each of the suppliers. Engineers may have five vendors knocking on their doors promoting their products, but this is not the case with wood.
5. Continuing education credits probably do not benefit engineers but would benefit architects.

Workshop No. 3—Engineers—June 6, 2007

General Observations Regarding Wood as a Non-Residential Building Material

1. Wood is being used by industrial and mid- and low-rise elementary schools.
2. Designing with wood is challenging and detailing can be stimulating, whereas steel design is pretty routine.

3. Because wood is so complex, wood designers need to be highly competent.
4. Working with wood actually teaches a young engineer how to design, as they must understand load paths. However, most firms do not have the capability nor the time to teach them.
5. Often young designers coming to firms do not have adequate training in wood design.
6. Carefully detailed structures, such as those needed for wood, do not always get built properly.
7. There is a need to educate contractors and implement field quality control (QC).
8. Engineers need to do more jobsite QC.
9. Owners need to be convinced that jobsite QC by the engineer is very important.
10. The need exists for special building inspector training.
11. Decay is a problem caused by lack of proper moisture detailing. This is addressed in residential construction, but not in commercial building design.
12. More durable products would be desirable.
13. Mixed-use structures offer an opportunity for upper stories, but mixing ASD (wood) and LRFD (steel and concrete) is a design challenge.
14. The city dictated all that wood be used for the new city hall in Tracy, California; otherwise, steel would have been used.
15. The cost of the steel compared with wood concept is a big factor. Engineers do not have budgets to redesign if steel is initially selected; therefore, initial material selection is a key factor.
16. Engineers need better cost information.
17. The use of wood is cost-driven, and the speed of installation favors wood.
18. Hotel chains use wood because it is less expensive.

Obstacles Facing the Wood Products Industry to Expand the Use of Wood in Non-Residential Construction

1. Moment-resistant frames are needed for commercial construction.
2. From a structural performance perspective, it is difficult to get wood to perform the same way as steel and concrete do.
3. High-load wood shear walls are needed; designers prefer to use concrete shear walls and steel-braced frames.
4. Changing nailing patterns around the roof with wood requires more complex analysis than does steel, which just requires more welds.
5. Wood floors have been used for second stories, but it is difficult to combine wood with a braced steel frame.
6. Seismic demands are difficult to achieve in commercial buildings using wood framing.
7. Tilt-up buildings are becoming more common in retail structures with dominant large openings that favor steel.
8. Using wood requires complicated rigid/flexible diaphragm analyses.
9. A heavy amount of detailing is needed for wood.
10. Plan checkers have problems with complex wood-frame structures and may not accept software analysis.
11. Help is needed for wood connections.
12. It is easier to design steel using welded connections.
13. Develop software for wood that is similar to other programs that are used extensively for steel. The Portland Cement Association also offers concrete design software.
14. The Wood Products Council needs to come up with software solutions, especially for lateral load.
15. Wood connections are not intuitively obvious, and wood has directional considerations that steel does not.
16. Diaphragm to shear wall connections is a major concern.
17. The deflection for wood portal frames must identify a degree of fixity.
18. The transfer of loads from a high to low roof is very difficult to achieve with wood.

Introduction of New Technologies

These new technologies are needed:

1. Fiber-reinforced polymer panels that increase stiffness and ductility.
2. Code-accepted FRP glulam that provides a cost savings.

Research Needs

1. Research should have an end purpose and not be research conducted for the sake of research.
2. A wood moment frame needs to be developed using something better than nails.
3. Revaluate prefabricated C- or L-shaped moment frame elements that can be bolted together at the jobsite.
4. Diaphragm capacity based on deflection is important and needs to be better understood.
5. There is a need to understand how to determine the R values for a wood moment frame.
6. Develop innovative shear walls that are not height limited. Consider developing 14-foot-high wood-framed

shear-wall solutions where buckling is a concern to compete with proprietary steel shear walls. Shear-wall calculations now need to consider rigidity. Is it a good assumption that the tributary area approach would be easier, if flexible performance is assumed?

7. Fire retardant treated (FRT) studs that come in contact with threaded steel hold-down rods are becoming a problem because of the corrosive effects of the treatment. Research needs to consider the effects of where the steel contacts the FRT material.
8. Conduct cyclic testing to evaluate the effects of eccentricity on end posts using hold downs.
9. Is it possible to better determine how shear wall performance is affected by small openings?
10. Performance of perforated shear walls under cyclic loading.
11. Mechanics-based approach or finite element analysis is needed for perforated shear walls.
12. The wood industry needs to be more active in diaphragm testing and not just accept what the metal deck industry is focusing on for design criteria.
13. Determine how flexible diaphragms really work.
14. Evaluate systems that reduce cost.
15. Need to tap into the southern California engineers for research guidance.

Education/Technology Transfer

1. The step-by-step “recipe” design has potential, if the design guideline includes examples in an appendix.
2. Detailing guidelines are needed.
3. Simplify the wood-design process for the designer, plan checker, inspector, and contractor.
4. Technical transfer of existing seismic information is needed for the regulatory agencies and design engineers.
5. Education for non-wood engineers and contractors is needed to minimize problems caused by inexperience.
6. Software programs would help designers track loads.
7. Justify the use of flexible diaphragm analysis and develop simplified design procedures.
8. Timber design at the university level is needed to teach principles with design examples.